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CENTRAL STATES FOREST EXPERIMENT STATION

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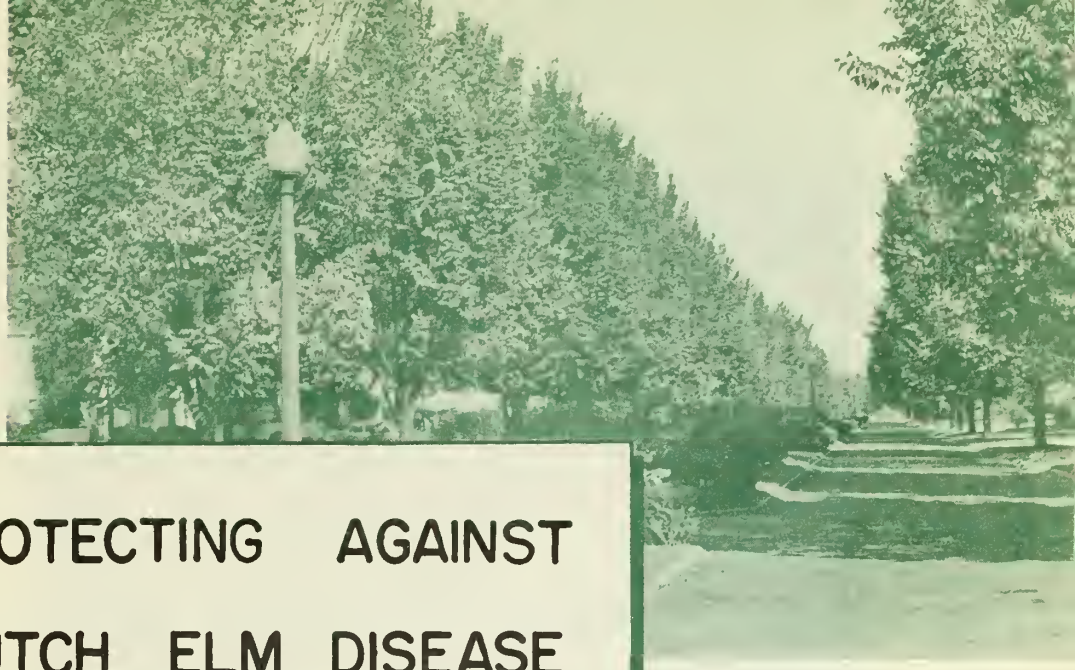

PROTECTING AGAINST DUTCH ELM DISEASE

RUSSELL R. WHITTEN, entomologist

Dutch elm disease destroys more elm trees in the United States than any other disease. It has been responsible for the death of hundreds of thousands of our valuable elm shade trees, and these losses are increasing steadily. This disease is known to be established in most of the states from the east coast to the Mississippi and beyond, and it is very likely that eventually it will occur wherever elm trees are grown.

The disease is caused by a fungus that was introduced into the United States some 35 years ago. As deadly as this fungus is to our elm trees, it would cause little concern if it were not for its insect carriers. It is entirely dependent on insects to move from one host to another.

The purpose of this paper is to present the latest recommendations for controlling the insect carriers of Dutch elm disease. Pertinent information on the habits of the major carrier are included so that the control recommendation may be better understood. Much of the information included herein has been published elsewhere and although no direct reference to these publications is made, a list of selected references is appended for anyone wishing additional or more detailed information.

All species of elm found in the United States may be attacked by the Dutch elm disease fungus. However, the Chinese elm has a high degree of resistance to the disease, and this species is rarely damaged. One European elm selection, the Christine Buisman elm, has been found to be very resistant to the disease, and is being propogated and distributed by several nurseries. Although workers have been searching for many years, no selection of our most popular elm, the American elm, has been found that will satisfactorily resist the disease.

In the United States the principal carriers are two elm bark beetles: the smaller European elm bark beetle (fig. 1) and the native elm bark beetle. The habits of these two beetles are very similar, and, since the European species is by far the most important carrier, no further discussion of the native species will be included in this paper. The usual result where both bark beetles are established is for the European species to completely displace the other, making it impossible to find our native species. The smaller European elm bark beetle, like the disease, was also introduced into the United States from Europe and it has already spread over an even greater area than the disease itself.

Federal and State research workers have studied Dutch elm disease and its insect associates for the past 22 years. The objective of these investigations was an effective and economical means for preventing or at least reducing the tremendous losses caused by these pests. Methods of control have been developed but there are still many problems which only more research can solve. For example, probably the most effective way to control Dutch elm disease would be to cure elm trees after they became diseased. Thus far research has failed to find such a cure, but indications are that such a treatment may eventually be developed. At the present time, however, the only known way to combat Dutch elm disease is through its insect carriers, an indirect method but one that has proved to be effective.

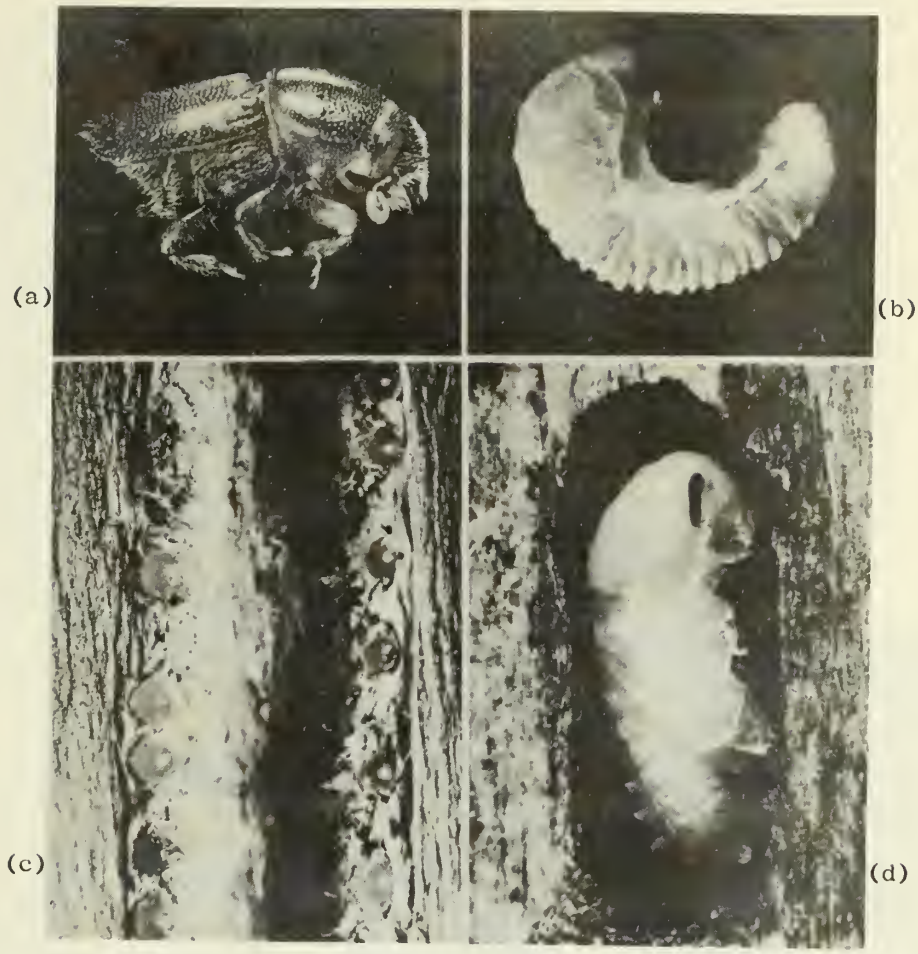

Figure 1.--Stages of the smaller European elm bark beetle (a) adult, (b) larva, (c) eggs, and (d) pupa.

HABITS OF THE BEETLE

The smaller European elm bark beetle will attack all species of elm, but only elm. The attacks made by this beetle are for either feeding or breeding. The feeding attacks are made only in living elm trees and then usually in the smaller twig crotches (fig. 2). The breeding attacks are made for the purposes of laying eggs and producing broods of young. These breeding attacks are made only in certain types of elm wood. Living elms in good growing condition are not attacked; but living elms severely weakened by drought are subject to attack. Generally this beetle is very selective in its choice of a breeding place. However, when populations of the insect reach high levels, attempts at breeding will be made in a much greater variety of places. Elm material such as trees rapidly dying from disease or injury, storm broken limbs, firewood, or any recently cut elm wood are preferred breeding places. Under no conditions will this beetle lay eggs in wood without bark or with bark that has dried to the point of cracking.

Figure 2.--Feeding injury made by elm bark beetle in twig crotch. Through these injuries elms may become infected with Dutch elm disease.

FEEDING HABITS

Adults of the smaller European elm bark beetle are in the field and feeding on living elm trees throughout the entire growing season of the elm. These adults start emerging from overwintering broods of larvae early in May. Depending on temperatures, the time required for a complete generation during the spring and summer varies from 35 to 45 days. The beetles do most of their feeding in the living elms nearest to the place from which they emerged as adults. However, the insect has been found feeding in elm trees more than 2 miles from the nearest breeding place. In areas where the population of the beetle is heavy, feeding may be so intense as to cause many small twigs to be pruned from the trees where the insects feed. Feeding injuries are most numerous in the twig crotches nearest to the periphery of the crown. However, twig crotches in the very center of the crown may at times be fed upon.

When the feeding beetles are carrying the Dutch elm disease fungus on or in their bodies, they can cause the living trees to become infected with the disease. How effective these fungus carrying beetles are inoculating healthy elm trees depends on many things, two of which have an important bearing on any control program. They are: time of feeding and age of twigs fed upon.

Time of Feeding

Feeding that takes place in the spring and early summer (May 15 to July 30 in the Central States) is more likely to result in successful and general infection than feeding before or after this time. This is because the long vessels of the elm spring wood are open and functioning at this time and are near enough to the bark surface that beetles in their feeding will cut into them. Spores of the Dutch elm disease fungus introduced into these long, functioning spring vessels can be carried rapidly to all parts of the tree. On the other hand, vessels of wood produced later in the summer are relatively short. Spores introduced into these much shorter vessels of the summer wood will move only short distances and will result in only very localized infections which seldom cause serious damage to the tree.

Age of Twigs

These long spring vessels rarely extend into twig crotches formed during the current year, hence feeding in this new growth is not likely to result in general infection and death. To sum up very briefly, bark beetle feeding in 1-year-old or older twig crotches during the spring and early summer is most likely to result in Dutch elm disease infection.

BREEDING HABITS

As soon as an elm bark beetle emerges from its breeding place, it begins searching for a place to rear its young. Although these beetles usually feed on living elms before mating and laying eggs, it is not necessary for them to do so. Beetles in search of suitable breeding places are in the field throughout the entire growing season (May into October for the Central States). There are records of these beetles laying eggs more than 3 miles from where they emerged as adults.

As was mentioned earlier, these beetles are very selective as to the condition of the elm material in which they establish broods of young. However, many times beetles have made so many attempts to breed in weakened but living trees that the trees eventually died and broods of the insect were successfully established. This has been particularly true in areas where elms have suffered from prolonged periods of drought. Any situation that results in a large amount of recently killed, cut, or damaged elm wood will cause tremendous increases in the population of this elm bark beetle. Conversely, anything done to reduce elm material suitable for bark beetle breeding over a large area will greatly reduce the numbers of this insect in that area. The area must be large enough to offset the effect of beetles flying in from outside.

If the smaller European elm bark beetle is carrying the Dutch elm disease fungus on or in its body when it makes its brood gallery, it may establish the fungus where it will grow as a saprophyte. Later, the new generation of adult beetles developing from this brood gallery may bring the fungus out on their bodies and either introduce it into living elms when they feed or into another breeding place, or both. In this manner, the Dutch elm disease fungus may be moved long distances any time during the entire active period of the adult beetles. When new areas are invaded by the bark beetle and by the Dutch elm disease fungus, the latter may be present in beetle breeding places as a saprophyte for several years before the first diseased tree is found. Probably one reason for this is that beetles are more successful in establishing the fungus in their breeding galleries than they are in living trees. However, once the disease does appear in an area where the bark beetles are well established, it increases at an unbelievable rate unless steps are taken to control it.

CONTROL RECOMMENDATIONS

The habits of the smaller European elm bark beetle in its relationship to the Dutch elm disease fungus indicate two ways by which losses from the disease can be reduced. The first way is to prevent or reduce feeding by the beetle in living elm trees, especially during the spring and early summer when trees are most susceptible to infection. This is done by spraying. The other approach is to reduce the population of the beetle by eliminating the kinds of elm material that it requires for breeding. This is a matter of sanitation.

SPRAYING

Materials

The most effective spray material for preventing elm bark beetle feeding is DDT in the form of an emulsion. The solvent used in preparing the DDT emulsifiable concentrate is important for two reasons. First, the solvent is the ingredient most likely to injure the foliage. Second, solvents that are too volatile result in premature crystallizing; solvents not volatile enough result in bark penetration. Either way, the surface deposit on the bark is reduced.

The formulas in tables 1 and 2 for preparing DDT emulsifiable concentrates have been found very effective. There are many commercial DDT emulsifiable concentrates that are similar in make-up to these formulas. They will probably do an equally good job.

Table 1.--Formula for use in hydraulic sprayers

Material	Percent by weight
DDT, technical grade	32.4
Xylol, industrial grade	58.6
Emulsifier1/	2.2
Acetone2/	6.8
	100.0

1/ Triton X-100 was used in the work discussed here. However, there are doubtless other commercial products that would serve equally as well.

2/ Acetone may be omitted if concentrate is to be stored at temperatures above 50° F.

Table 2.--Formula for use in mist blowers

Material	Percent by weight
DDT, technical grade	26.6
Xylol, industrial grade	47.5
White horticultural oil	23.6
Emulsifier	2.3
	100.0

1/ Acme white oil was used in the work discussed here. However, there are doubtless other white horticultural oils that would serve equally well.

Sometimes DDT sprays destroy many of the beneficial insects. This results in abnormal outbreaks of such pests as scale insects, mites, and aphids. For the control of scale insects, a dormant oil may be added directly to the diluted DDT spray. There are several miticides such as Ovatron, Dimite, and Aramite that may be added to the diluted DDT spray to control mites. For controlling aphids, add BHC to the DDT spray.

Equipment

DDT sprays for the control of elm bark beetle feeding may be applied with hydraulic-type sprayers or the newer mist blowers (fig. 3). There are certain advantages to both, but the equipment used must be adequate to treat the largest elm tree that might be encountered. Hydraulic sprayers hauling an output of 60 gallons per minute at pressures up to 600 pounds per square inch will satisfactorily spray trees 100 feet high, provided of course that the spraying is done when there is little or no wind. Trees of the same size and under similar conditions have been satisfactorily treated with a mist blower having an air output of 25,000 cubic feet per minute at 100-miles-per-hour nozzle velocity. Spray output on mist blowers should be at least 1 gallon per minute.

The success or failure of a spray program for Dutch elm disease control depends on the kind and type of equipment used. The reader who has a particular problem in spraying is referred to Mr. S. F. Potts of the Northeastern Forest Experiment Station, 111 Prospect Street, New Haven, Connecticut, for equipment specifications. Mr. Potts is an expert on spray equipment.

Figure 3.--Two types of spraying equipment: hydraulic sprayer (left), and mist blower (right).

Spray Concentration and Dosages

For applications when trees are dormant, the DDT emulsifiable concentrate should be diluted with water so that each 100 gallons of spray for use in hydraulic equipment contains 16 pounds of technical grade DDT, and each 100 gallons of spray for use in mist blowers contains 100 pounds of DDT. Using the formulas given here, 5.6 gallons of concentrate are required for each 100 gallons of spray for use in hydraulic sprayers, and 24.5 gallons of concentrate for each 50 gallons of spray for use in mist blowers.

In spraying with hydraulic spray equipment, enough spray should be applied to thoroughly wet all bark surfaces. This usually requires from 20 to 30 gallons for an average 50-foot elm tree. For mist blowers, between 2 and 3 gallons of spray are needed to adequately treat a 50-foot elm. When using hydraulic sprayers, once the bark surface is completely covered, the excess spray will run off. But when using mist blowers, spray deposits dry so rapidly that they can be built up to a point well beyond what is needed without any run-off.

Dosages recommended by the manufacturer should be used when materials are added to the DDT spray for mite, aphid, or scale control.

Bark Coverage

It is impossible to overemphasize the importance of completely covering all bark surfaces with DDT spray when attempting to prevent bark beetle feeding. Complete coverage of all bark on the trunk, limbs, and twigs will not only prevent feeding by adults of the smaller European elm bark beetle but also prevent feeding by all other known insect carriers of the Dutch elm disease. Bark coverage can be greatly improved by using a 2-man crew: one man to spray and the other observe. The observer should stand some distance away from the sprayer operator so he can see exactly where the spray is going and how much is being deposited. Regardless of how well a tree is sprayed, each additional spraying improves the coverage. This is true because DDT spray deposits on elm bark retain some effectiveness for 2 years or longer. DDT emulsion-type sprays dry very rapidly and, unless it rains within an hour after spraying, there is very little loss of deposit from washing.

Time to Spray

Elm trees should be sprayed before the smaller European elm bark beetles become active in the spring. Good spraying days have little or no wind, no rain, and temperatures above freezing. Because of the long residual effectiveness of these DDT sprays, this dormant application can be made any time after the elm trees lose their leaves in the fall and before the new leaves or flowers appear in the spring. An annual dormant spray will remain effective throughout the period that elm trees are most susceptible to infection. A second application at one-half the strength of the dormant spray may be made in July to prevent late summer feeding. Such a spray probably accounts for very little disease control, but it does improve bark coverage, resulting in better control of bark beetle feeding. However, a foliar spray is more likely to destroy beneficial insects, which may result in abnormal outbreaks of such pests as scales, mites, and aphids.

It is impossible to adequately cover the bark with sprays applied for the first time when the tree is in foliage. So it is advisable to begin any spray program when the trees are dormant.

SANITATION

Sanitation, or the control of elm bark beetles by destroying their breeding places, will not under most conditions give good results in controlling Dutch elm disease. For example, in a plot of 27 square miles in Princeton, New Jersey, sanitation was carried on diligently to protect the high-value elms in the very center of the plot. In the treated area, Dutch elm disease killed nearly 13 trees per 1,000 over a 3-year period and less than 20 per 1,000 in an "unsanitated" area or check plot. When the center trees in this same plot were sprayed, the losses over a 3-year period averaged only 3.0 per 1,000 trees as compared to 31.3 trees per 1,000 trees in the check or unsprayed plot.

Here are a few reasons why sanitation fails where sprays succeed:

1. Adults of the smaller European elm bark beetle can fly and carry the Dutch elm disease fungus for at least 3 miles.

2. It is often difficult for towns or property owners to carry on sanitation beyond the area under their jurisdiction, whereas the beetles can fly anywhere.

3. If sanitation is to be effective, all elm material infested with broods of this bark beetle must be located and destroyed before the adult beetles emerge. During the spring and summer months, this calls for very prompt action because of the rapidity with which this insect develops from egg to adult.

4. In most areas there are many more elms growing in wild low-value stands than there are growing as shade or ornamental trees. So it is expensive and difficult to locate all breeding places. Moreover, elm trees that have no external signs of dead or dying wood, may well harbor many broods of the bark beetle.

On the other side of the ledger, there are many good reasons why sanitation should be carried on. Here are just a few of them:

1. Dead and dying parts of trees frequently harbor injurious fungi and insects (fig. 4). So it is a good practice to include sanitation in any program for the care of shade trees.

2. Sanitation will definitely reduce the number of bark beetles in an area and hence will enhance the chances of sprays being effective against insect feeding.

3. Sanitation can be begun as soon as the bark beetles invade an area. By starting early to reduce the number of bark beetles and probably the saprophytic form of the Dutch elm disease fungus, the appearance of diseased trees can be delayed.

4. Only by sanitation can non-symptomatic reservoirs of the Dutch elm disease fungus by destroyed.

To make your sanitation program fully effective, this is what to do:

1. Destroy no later than April 15 all elm material infested or likely to be infested with elm bark beetles found during the dormant period.

2. Destroy within 30 days similar material found between April and September.

3. Carry on sanitation in stands of low-value elms as conscientiously as in stands of high-value elms.

4. Search regularly and systematically for bark beetle breeding places.

5. Destroy elm material containing larvae of the smaller European elm bark beetle before you destroy elm material classed as potential breeding places. Trees infected with Dutch elm disease but not yet infested with the bark beetle are potential breeding material.

There are three ways that bark beetle infested or likely to be infested elm material can be destroyed.

1. By burning.

2. By removing and burning all the bark.

3. By thoroughly wetting all bark surfaces with an emulsion- or solution-type spray containing 8 pounds of DDT in each 100 gallons. If solutions are used, the solvent should be No. 2 fuel oil.

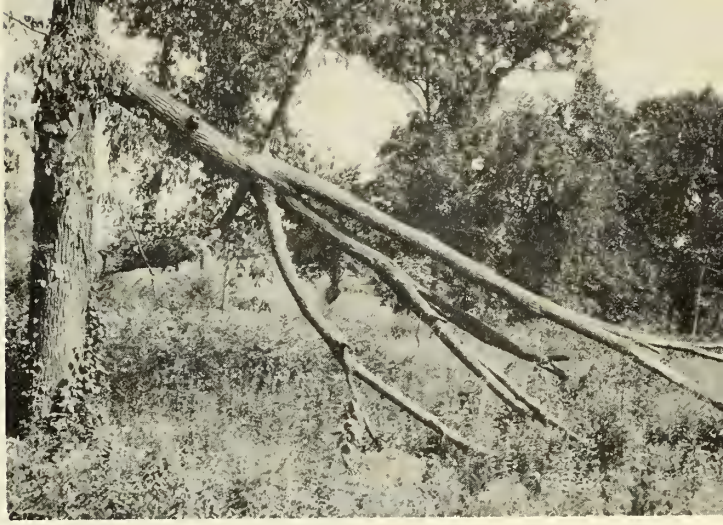

Figure 4.--Storm-damaged trees make ideal breeding places for bark beetles.

SUMMARY

1. The principal carrier of Dutch elm disease in the United States is the smaller European elm bark beetle.

2. The only sure way to control Dutch elm disease is to control its insect carriers.

3. There is no cure for elm trees once they become infected with Dutch elm disease.

4. Elm bark beetles and the Dutch elm disease fungus may become established in an area several years before the first appearance of Dutch elm disease.

5. Spraying healthy elm trees with DDT sprays is effective in protecting them against Dutch elm disease.

6. Sanitation will reduce elm bark beetle populations and supplement the use of sprays for Dutch elm disease control. As a primary means of control it is usually ineffective.

7. Control of elm bark beetles by sanitation should be begun as soon as they are found in an area. This will delay the occurrence of Dutch elm disease.

8. A selection of the European elm, known as the Christine Buisman elm, and the Chinese elm are the only elm trees recommended for planting. These two elms are highly resistant to Dutch elm disease.

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